U. S. DEPARTMENT OF AGRICULTURE.

FIBER INVESTIGATIONS. REPORT NO. 6.

A REPORT

ON THE

UNCULTIVATED BAST FIBERS

OF

THE UNITED STATES,

INCLUDING

THE HISTORY OF PREVIOUS EXPERIMENTS WITH THE PLANTS OR FIBERS, AND BRIEF STATEMENTS RELATING TO THE ALLIED SPECIES THAT ARE PRODUCED COMMERCIALLY IN THE OLD WORLD.

BY

CHARLES RICHARDS DODGE,
SPECIAL AGENT.

PUBLISHED BY AUTHORITY OF THE SECRETARY OF AGRICULTURE.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
OFFICE OF ASSISTANT SECRETARY.
Washington, D. C., March 15, 1891.

SIR: I have the honor to transmit herewith, for your approval, a special report on the uncultivated bast fibers of the United States, prepared under my direction by Mr. Charles Richards Dodge, special agent in charge of the fiber investigations of this Department. As these fiber plants are a source of constant inquiry by correspondents of the Department, I take pleasure in recommending its early publication.

Very respectfully,

CHAS. W. DABNEY, Jr.,
Assistant Secretary.

Hon. J. STERLING MORTON,
Secretary.

LETTER OF SUBMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
OFFICE OF FIBER INVESTIGATIONS,
Washington, D. C., March 10, 1894.

SIR: I have the honor to submit herewith the manuscript for Report No. 6 of the Fiber Investigations series, referring to the indigenous or uncultivated plants of the United States whose bast is known to contain fiber of greater or less value. The publication of the life history, and the description of the uses of these fiber plants by the Department is important, not only because the literature of the subject, as it pertains to our own country, is so meager, but from the fact that frequent inquiry is made concerning the different forms by correspondents of the Department.

In connection with the native species and those introduced and now perfectly naturalized, herein described, I have referred to a few allied foreign species that have been cultivated to some extent in the Old World, for the sake of comparison or to supply hints regarding growth or preparation of the fiber of our own forms. Examples of the fiber from all these native forms were represented in the Department's Fiber Exhibit at the World's Columbian Exposition. A report on the cultivated bast fibers, containing new and useful information, and another report relating to the palm and miscellaneous fibers will follow this publication.

I am, sir, respectfully, yours,

CHAS. RICHARDS DODGE,
Special Agent, in Charge of Fiber Investigations.

Hon. CHAS. W. DABNEY, JR.,
Assistant Secretary.

CONTENTS.

ILLUSTRATIONS.

UNCULTIVATED BAST FIBERS OF THE UNITED STATES.

INTRODUCTORY.

The indigenous or uncultivated species of plants producing bast fiber in the United States form an interesting group in the fiber series. They are the subject of constant inquiry, as the masses of their filaments, disintegrated and semi-bleached on the parent stalk by the winter storms often attract the attention of the farmer, who, regarding his discovery as new, and considering it the source of a valuable, undeveloped industry, writes the Department to learn the name and history of the species.

For the most part the species under consideration belong to three large families of plants: the *Malvaceæ;* of which the cotton plant is a member; the *Asclepidaceæ*, and the *Leguminosæ*. The malvaceous species are the most numerous, and possibly the most widely distributed, their fiber possessing fair strength, comparing with jute, rather than with flax and hemp, though whiter in color than the former. These I would consider as "jute substitutes," while the species belonging to the two other families, and which give stronger fiber, may be termed "hemp substitutes," and are, therefore, the more valuable.

That these fibers are not employed commercially is due to several causes, the machine question being an important factor. The facts that flax and hemp can be readily grown over large areas of our country, and that the cultivation of these plants and the manipulation of the fiber are matters well understood, have prevented some of the native forms from being brought into prominence in northern localities favorable to their growth, while the cheapness of commercial jute has kept back the culture of others, particularly in the South, where they might readily be produced.

Nevertheless, some of these species have been regarded with high favor in the Old World, where they have been cultivated to some extent and where the fiber is prepared cheaply, though by primitive methods that could not be adopted in the United States. In these countries the product is usually manufactured in or near the localities of growth and is considered of "local" rather than of "commercial" importance. This gives us a hint as to the possible utilization of some of our own species; for while it might be difficult to produce fiber that would be marketed with the commercial cordage fibers, small local industries

might be established to grow the fiber and utilize it in such manufactures as would enter exclusively into home consumption. For many purposes sisal and manila cordage only can be employed, but, at the same time, considerable quantities of sisal and manila cordage are employed in uses for which the cheaper, home-grown fiber would be just as well adapted.

The first thing to be considered, however, is the question of economical production. What will it cost to grow an acre of stalks, and what will be the expense of stripping and cleaning the fiber? Until these questions can be satisfactorily answered, the cultivation of the fiber must be considered as still in the experimental stage, and it would be unwise to go into the culture expecting sure remuneration. The machine question, as stated, is an important factor in the problem. The hand methods in vogue in many foreign countries where such fibers have been successfully produced are unsuited to the progressive ideas and spirit of enterprise which underlie all American agricultural and industrial practice. For example, our farmers will never stand, waist deep, in pools of stagnant water to thrash off the fiber of several acres of stalks, a handful at a time. This suggests the use of machinery at least for stripping the bark from the stalks, the fiber to be cleaned and prepared by after-processes which, however, do not concern the grower. The bast of hemp has been stripped from the stalk for a hundred years by means of a cumbersome hand-brake, the fiber being first softened by some form of retting. With the advent of a satisfactory hemp-brake we shall doubtless have a machine that will decorticate all of these so-called hemp and jute substitutes, and if their cultivation can be shown to cost no more than the cultivation of hemp, there is a possibility that their production may some day become industries.

Many machines have been invented in past years, which for one reason or another have been found impracticable. Some have possessed merit, and a few have shown promise, when further improved, of giving full satisfaction. It should be noted that in referring to such machines we are not considering those for decorticating or defibrating ramie, though the successful ramie machine, when it appears, doubtless may be used as successfully, with slight modifications, for cleaning bast fibers in general. The machine question, as regards hemp and the hemp and jute substitutes, may not be regarded, therefore, as an immovable stumbling-block in the way of utilizing these fibers economically, for the efforts of American inventive genius must in time be crowned with full success.

The object of this report, then, is twofold: First, to call attention to American fiber plants that are classed as weeds in the botanies, and which may some day be grown industrially, and, secondly, to give in condensed form their history, uses, etc., for the benefit of the many inquirers who, regarding them of possible value, may wish to know more concerning them.

The experiments herein recorded have, for the most part, been carried on by private enterprise and not under the auspices of the Department; and the Office of Fiber Investigations gives them prominence only because they form an interesting record of past experimental effort that will serve for the information and guidance of others who may desire in the future to carry them further and possibly to a successful end.

It should be stated that the species of okra and abutilon, while belonging to the *Malvaceæ*, are treated in special chapters because of the prominence that has been given to these fibers through the efforts to utilize them in the industrial economy.

THE MALVACEOUS FIBERS.

Hibiscus, species, et. al.

The family *Malvaceæ* is a large group of fiber-producing plants, found chiefly in tropical countries, though extending into temperate climates, some of the species in other countries being of commercial importance. The American species of *Hibiscus* and allied genera grow in many portions of the United States, North and South, though they have never been cultivated for their fiber, save in an experimental way.

Vétillart states that the fiber of hibiscus, when minutely examined in glycerin, appears as a bundle, the filaments strongly united together, so much so that they are with difficulty separated even after treatment in an alkaline solution. The fibers are short, stiff, and brittle; of sufficient fineness, but irregular in size, even in the same specimens. The central cavity, usually narrow, is prominent; cells generally terminating in fringed points, sometimes having notches or sinuosities in their outlines; some are large, ribboned, and creased, the exterior surface striated. These last have very slender walls, which explain the creases. Viewed transversely with a high power the fibers are seen to be polygonal, with sharp angles and straight sides, the polygons pressed compactly together. The walls are thick and the central cavity round or oval.

THE SWAMP ROSE MALLOW.

This is one of the commonest of the mallows, known botanically as *Hibiscus moscheutos*, and found in many parts of the temperate United States, according to Gray "inhabiting brackish marshes along the coast, extending up rivers far beyond the influence of salt water (as above Harrisburg, Pa.), also Onondaga Lake, New York, and westward, usually within the influence of salt springs." The plant grows from 4 to 8 feet in height and flowers late in summer. (*See* Plate I.)

Experiments with this plant date back many years, and fifteen years ago it was the subject of renewed experiment in New Jersey, the advent of new machinery for cleaning bast fibers calling attention to the plant, and placing its cultivation for fiber among the possibilities. In the second report of the bureau of statistics, labor, and industries of New Jersey (1880), statements were made as follows:

> Recent experiments with the rose mallow at Camden and Newark incline us strongly to believe that jute of equal quality may be obtained from it, and possibly

THE SWAMP ROSE MALLOW (*Hibiscus moscheutos*).

under conditions more advantageous than from the Abutilon (*A. avicennæ*). One very important advantage the rose mallow would have over the Abutilon, in respect to the economy of cultivation, consists in its being a perennial. Like ramie, the plants once established, the annual cuttings from the stands would be a perpetual source of profit to the cultivator, in case the quality and cost of the fiber meet our present expectations.

Although the plant is generally found, in a wild state, in marshes, or upon the margin of streams, or in low, wet places, experiments show that it will thrive upon uplands as well. Thirty-five years ago rose mallow roots were taken from the place of their natural growth and planted upon uplands on the Delaware River, with a view to utilization of the fiber, and for many years they held their own as tenaciously as when growing in their native swamps; and they may be growing upon these uplands to-day, from all that is known to the contrary. Samples of fiber from the New Jersey experiments of fifteen years ago were considered not only as good as India jute, but "as secondary grades of imported hemps."

An effort was made by the Department last season to secure sufficient fiber for test in comparison with jute and other commercial cordage fibers. Seed was secured from Pennsylvania, and this was planted for the Department, but those who undertook the experiment failed to report any practical results. I am unable, therefore, to make statements regarding the strength of the fiber, and must regard the conclusions relating to the New Jersey experiments, quoted above, as mere conjecture.

THE ROZELLE HEMP PLANT.

This is the "Jamaica Indian Sorrel" (*Hibiscus sabdariffa*), the plant which furnishes the "rozelle" (or oiselle) hemp of the Madras territories. In India it is a small bush, cultivated in many portions of that country, its stems yielding a strong silky fiber by retting the twigs when in flower. Its fleshy calyxes, of a pleasant acid taste, are much employed for making tarts as well as jelly, and in the West Indies the fruit is much esteemed for making cooling drinks. Another culinary use of the plant in India is the preparation of its leaves in salads. The species grows in southern Florida, where it is planted in March and comes to maturity in December.

Mr. E. N. Knapp, of Tarpon Springs, Fla., states that the plant thrives in cultivation, but that it will not stand much frost. It will grow on quite poor land, though it does best on good land, where it reaches a height of 8 to 10 feet. It can be produced from cuttings as well as from seed. Even in Florida it is much esteemed for its fruit, which is used soon after the blossoms fall. It is said to make an excellent jelly, and is used as a sauce much as the cranberry is used in the Northern States.

A superb sample of this fiber was shown in the exhibit of British Guiana, Chicago, 1893, which was accompanied by the stalks some 10

feet high, as straight and clean as jute stalks. The fiber is produced only experimentally in that country, but it might be used commercially if that shown was an average sample.

A FLORIDA SPECIES.

Another malvaceous plant which grows wild all over India, and which is common in Florida, is *Urena lobata*. It also abounds in South America, its Brazilian name being *Guaxima*, or *uaixyma*,* while it is known in Venezuela as *Cadillo*. Its Indian name is *bun-ochra*, the natives of India considering its fiber useful for manufacture into sacking and twine. It is called a "tolerable substitute for hemp." (*See* Plate II.)

Dr. Ernst, director of the national museum, Caracas, Venezuela, describes the fiber as very fine, white in color, and a meter in length. It is very strong, and takes dyes readily.

Fiber of *Urena lobata* was received from Brazil (exhibition, 1876), where it is extracted readily and makes very strong cordage. "It takes color well, and the dyes are lasting." In the East Indies it has been used for the manufacture of paper. Spon states that slips of sized paper weighing 39 grains made from this fiber sustained 75 pounds against bank of England note pulp 47 pounds. *Urena sinuata* is another Indian species.

I have found *Urena lobata* growing in many portions of Florida, both on the east and west coasts, though I have never seen its slender stalks over 3 feet in height. It was several times pointed out to me as "ramie," by people who had never seen the true ramie growing. Recently the plant has been sent to the Department from several localities in Florida and one in Indiana with inquiries as to its value commercially. A common name which attaches to the plant in Florida is "Cæsar weed."

SIDA FIBER.

Sida is another genus of malvaceous plants found in both hemispheres, their bast being rich in fiber. A beautiful example of the fiber of *Sida retusa*, known as "Queensland hemp," was received by the Department in 1876 from the Queensland collection (Philadelphia Exhibition), accompanied by another specimen from Victoria labeled *Sida rhombifolia*. The first named was prepared by Dr. Guilfoyle, who states that the plant has established itself in Melbourne, and is of very quick growth, seeding freely. He regards the fiber as suitable for fine paper and for the manufacture of cordage.

The sample of *S. rhombifolia* is very white and lustrous, the filaments fine and even. In a portion of the sample the ribbon-like character of the bark is retained, filled with delicate indentations, giving it a lace-like appearance. These ribbons of fiber break easily, but a twisted cord of the finer prepared fiber, the size of cotton wrapping-twine of

* "Notes on the State of Para." Chicago Exposition, 1893.

THE CÆSAR WEED (*Urena lobata*).

the shops, broke only after repeated trials with the hands. The fiber was prepared by Alexander McPherson. This species grows in India and the bark yields "abundance of very delicate flax-like fibers," which Dr. Roxburgh thought might be advantageously used for many purposes. Forbes Watson, in the Descriptive Catalogue of the East Indian Department, International Exhibition, 1862, pronounces the fiber similar to jute in appearance, "but considered to be intrinsically so superior that it is worth from $5 to $6 more per ton, and he places it next that fiber" in order to attract to it the attention which it deserves.

S. rhombifolia abounds in many portions of South America. In Venezuela it is called *Escoba*. Dr. Ernst states that it is very common in that country, growing wild in all localities. "The fiber is readily extracted and is fine and strong."

Experiments with the fiber of *S. rhombifolia* demonstrated the fact that a cord one-half inch in circumference would sustain a weight of 400 pounds. In speaking of Dr. Roxburgh's specimens, Royle says "the fibers are from 4 to 5 feet in length, and display a fine, soft, and silky fiber, as well adapted for spinning as jute, but infinitely superior." The specimens of Queensland hemp in the Department collection are very well prepared, and quite strong; the fiber, in color, is grayish-white. The Victorian sample, while strong, is dark colored, and has been poorly cleaned.

As far back as 1889, the Office of Fiber Investigation received from South Carolina statements regarding *S. rhombifolia*, which, on the authority of Mr. J. P. Porcher, of Eutawville, in that State, had been known as a weed throughout that region for many years, at least since 1880. Later, when visiting Charleston, my attention was called to the plant by Dr. Panknin, who stated that it had made its appearance in comparatively recent years, and was now a common roadside weed. As it was early in June, the stalks had not sufficiently matured to give particular evidence of value as a fiber plant, although later some good hand-prepared samples of the fiber were secured.

Learning that Hon. G. D. Tillman, of Charles Hill, S. C., had cultivated the species as a forage plant, I wrote to him for statements regarding it, and in time received a reply, dated October 10, 1890, from which brief extracts have been taken, as follows:

> I have several acres of this plant growing for pasture only. It is neither fit for hay nor for soiling, but it is a good pasture plant for cattle, sheep, and hogs. Horses do not seem to relish it much, while cattle in particular appear to like it and thrive on it almost as well as upon Japan clover (*Lespedeza striata*). The plant has a wonderful tap root and a large leaf, besides the habit, where left to reseed itself, of standing very thick on the land and shading almost every inch of the surface of the soil. For these reasons I have thought it must be an excellent green manure plant, and am trying some experiments to test it as such. It looks very much like Lespedeza when young, comes up early in the spring and remains green till frost. It spreads rapidly in waste clay land along fence rows, in brier patches, etc., but on account of the seed being much larger it does not spread nearly so fast as Lespedeza. I never have seen it growing on sandy soil. It affects hardpan altogether, either clay or compact gravel.

I do not remember seeing a sprig of *S. rhombifolia* until about four years ago, when a small patch of it first appeared in the back yard of my residence, whence it has spread over the yard, covering an acre or more of land, and scattering sprigs of it are appearing here and there at numerous localities over the large plantation. Last summer I saved 3 or 4 bushels of seed, and in the fall scattered them about in waste places and in my pasture, with what result I can not tell, as I have had no opportunity to make an examination on account of having been detained at Washington all the year. I was so much interested in the plant for pasture and green manure that when I came on at the opening of the present session, last December, I brought a sprig of Sida with me to submit to Dr. Vasey for identification and name.

I am glad to hear from you now that my mucilaginous pet Sida, "when planted thickly and allowed to mature, produces a fine fiber," a virtue I did not dream it possessed, although I had often observed the great toughness and strength of its bark. In canvassing the Second Congressional district and traveling about the State last year, I discovered the plant flourishing in the waste places of the streets in nearly every village and town. I also found it thriving in the lanes and along the roadside of the forest lands in the Tertiary formation, or "low country" of South Carolina, where a clay subsoil prevails, and wherever there was moisture as well as clay (in a shallow ditch, for instance) each separate sprig of thick-growing Sida was 3, 4, and sometimes 5 or 6 feet high. One striking peculiarity of the plant is that a single sprig growing by itself will bunch, or rather branch out from the stem just above ground, so as to resemble a squatty thicket of many short-limbed shrubs—with only one root, however—but when the sprig grows thickly, each from its own root, the plants are straight and without limbs, or knots, on the stems, except at the very top, and as tough as hickory, boxwood, or perhaps any other wood.

The popular name of *S. rhombifolia* in Lower Carolina is "Tea Plant," and there are millions of acres of land with clay subsoil in that section of the State well adapted to its growth, much of which can be cheaply irrigated if necessary in case the plant should prove commercially useful as a fiber yielder.

About this time it was learned that Mr. Volney Dunning, of Atlanta, Ga., had been experimenting with the Sida for its fiber, and an interesting correspondence followed. Seed of *Sida retusa* was imported by him from Australia in March, 1890, and planted in April. The seed was nearly six weeks in germinating, and the plants grew very slowly during the next six weeks after making their appearance. Their growth was rapid in August and September, however, and some good stalks, measuring almost 5 feet in length, were obtained. No fiber from these stalks was received by the Department, although a lot of the stalks were shown in the fiber collection of the Department at the Chicago Exposition. In a communication to Mr. Dunning from the Technological Museum, Sidney, some interesting statements regarding this species are made, the plant being called "Paddy Lucerne." Extracts are as follows:

Paddy Lucerne just as frequently goes by the name of Queensland hemp, and is fast becoming a noxious weed in the coastal districts of New South Wales and Queensland, although it thrives most in the warmer latitudes, i. e., as far south as Richmond and Florence. Its botanical name is *Sida rhombifolia* (*retusa*), Linn., and it belongs to the natural order *Malvaceæ*, a natural order notorious for the number of useful fibers it contains. The fiber is somewhat like jute, but it appears even superior to that well-known article. One plant is closely allied to the *Sufet Bariala* of India (*Sida rhomboida*, Roxb.), the fiber of which was described as "delicate flax-like fibers of great strength." It appears to be in every respect superior to jute. The

better known fibers of India Rosella hemp (*Hibiscus sabdariffa*) and Ambaree or Brown hemp (*H. cannabinus*) are both of them closely allied to our fiber, and the plants flourish in similar situations.

The plant in Queensland grows from 3 to 6 feet in height, and the value of the fiber has been stated from $150 to $200 per ton. *S. retusa* is one of the varieties of *S. rhombifolia*, of Linn, six being recognized in India. Another variety which has been experimented with in India with good results is the *S. rhomboidea*. It has been demonstrated by experiment in that country that Sida fiber is superior to jute, that under hydrolysis, or bleaching and cleaning with alkali, "it loses a very much smaller proportion of its weight, is therefore less easily disintegrated by the action of water, and is consequently more durable." The fact that its stalks are not more than half the length (or size) of jute is a disadvantage, compared with jute, as indicating a much smaller yield. George Watt, of the Revenue and Agricultural Department of India, was of the opinion, regarding the Indian experiments, that the properties of the Sida fiber recommended it as worthy all the time and expenditure necessary to ascertain whether or not all its advantages are counterbalanced, from the money standpoint, by a less acreage in yield.

Thirty years ago the fiber of "*Sufet bariala*" (*S. rhomboidea*), as produced in India, was considered worth from $25 to $30 more per ton than jute.

In a report on the Colonial and Indian Exhibition of 1886, the special advantages of Sida fiber over jute are stated to be: The fineness of the fiber ("it is not half as coarse as jute") as well as its purer quality, enabling it to be spun into finer yarns than jute, which would bring it into uses that jute has never been able to reach. It takes dyes better than jute, and is a better color in its raw state, being described as "a beautiful silvery white."

My own conclusions regarding the cultivation of the plant on American soil—based upon the results of limited experiment, it is true, and from examining stalks from different localities—would lead me to state that the plant is too slow in growth, and the stalks too small when grown, to make it of commercial value as a fiber plant. And it is doubtful if the bast will yield as readily to treatment as jute, for when steeped in water it is said to require almost double the time necessary to properly macerate the jute bast.

COTTON-STALK FIBER.

The cotton plant of Southern agriculture, *Gossypium herbaceum*, also belongs to the *Malvaceæ*, and it may not be known, generally, that its stalks contain fiber of good quality.

In the collection of fibers sent to the Paris Exposition of 1889 was a fine example of the fiber of the cotton stalk, from a plant grown by Gov. J. B. Gordon, of Georgia, prepared by the American Consolidated Fiber Company, from a green stalk, sixty days from date of planting.

In the letter transmitting the specimen it was stated that "the fiber is not only good for thread, but for a thousand other purposes; it is a splendid fiber for paper also, as it will not tear as easily as that made from wood pulp or rags."

There is no doubt that this fiber would make an admirable twine, though its use in "thread" is somewhat overstated. It possesses fair strength, specimens I have examined by hand tests appearing somewhat stronger than jute. The fiber of old stalks that have stood in the field is of varying shades of russet in color, while that from fresh stalks is a yellow white.

The antagonism of the farmers of the South to the jute trust, in 1890, called renewed attention to unutilized southern fibers for the manufacture of bagging with which to bale the cotton crop, the price of bagging having been advanced from 7 to 12 cents per yard. Various fibers were suggested as substitutes for the India product, and among them the bast of cotton stalks, which, it was claimed, could be supplied "from the 18,000,000 acres of cotton fields" in cultivation in the South.

Among those who experimented with this fiber in manufacture was Mr. William E. Jackson, of Augusta, Ga., who gave considerable attention to the enterprise, a company having been organized to carry on the work. According to statements made by Mr. Jackson, the fiber was separated "on a machine which was patented and perfected for South American fiber experiments," the name of the inventor not having been given. The principle consisted in "running the bast between a corrugated drum revolved by an eccentric attachment on a similarly corrugated concave bed, the charge between being washed by a flowing stream of water to wash away the residue of gum and bark."

No statements were made as to the method of harvesting the stalks, although the sample of fiber submitted was said to have been made from stalks that had been gathered late in February, after exposure to the weather for several months. The fiber produced from these stalks was sent to Mr. J. C. Todd, of Paterson, N. J., for manufacture, a few yards having been prepared experimentally. During a visit to the factory in Paterson, a few months later, I was able to secure from the loom whence it was made a small specimen of the bagging, which is preserved in the collection of the Department. The fiber, which showed fair strength, was reddish in color, or a bright russet, though the sample exhibited at Paris approached nearer to straw color.

Naturally the proposed new industry created considerable interest in the South, and the prediction was made that when properly developed it would become a source of great wealth to the Southern people. It was proposed to place the decorticating machines in sections of the country convenient to the bagging mills, that the fiber might be prepared, baled, and shipped as economically as possible. It was also claimed that the water or steam power employed in running the gins could be used to operate the fiber machines.

Like many other similar enterprises, the anticipated results were not realized, whether through the failure of the decorticating machines to turn out the fiber at economical cost, or for other reasons, can not be stated. I do not think that the machine question was altogether at the bottom of the difficulty, considering the kind of raw material that the machines were expected to work upon. A machine constructed to operate upon straight, clean stalks half an inch or more in diameter, grown rapidly and close together in the field, like hemp stalks, could hardly be expected to work smoothly upon the rough, irregularly shaped branches and often crooked material that would be yielded by cotton plants grown primarily for lint cotton. I am of the opinion that the harvesting of such rough and uneven material could not be accomplished at economical cost, even if such stalks or branches could be successfully cleaned. In a recent letter I am informed that the enterprise has not been altogether abandoned, though nothing has been accomplished for several years, so far as I can learn.

THE FOREIGN SPECIES OF HIBISCUS.

The most valuable foreign species of this genus is the "hemp-like Hibiscus" (*H. cannabinus*). The plant is a native of the East Indies, and at present is largely cultivated for fiber throughout India, the product being almost wholly utilized by the agricultural classes where grown as a substitute for hemp. Its common names are Decan hemp and Ambari hemp, the latter particularly in western India. In Madras it is called *Palungoo*. It is the *Mæsta* plant of Bengal and Deckanee hemp of Bombay. The Sanskrit name is *Nálika*. The plant has a prickly stem, the leaves deeply parted, and the stem attains a height of 6 to 8 feet. The fiber is described as soft, white, and silky, and by some writers is said to be more durable than jute.

Though thriving at all seasons of the year, it is generally cultivated in the cold season. The seeds are sown as thickly as hemp, in rich, loose soil, and it requires about three months' growth before it is ready to be pulled for "watering" and dressing, the mode of treatment being the same as that given the sunn hemp, *Crotalaria juncea* (see page 42). Full-grown plants that have ripened their seed furnish stronger fiber than the plants cut while in flower, though the fibers of this species are more remarkable for their fineness than for strength.

In harvesting, the plants are either cut close to the ground or pulled up by the roots, as the lower portion of the stem contains the best fiber. The stalks are submerged in water and allowed to remain from six to ten days, according to the weather, when the bark can be readily peeled by the hand. Too long steeping, while it makes white fiber, results in a loss of strength.

In a report of the Revenue and Agricultural Department of India another account is given, as follows:

The fiber is prepared by bundling the stalks, which, after a few days, are steeped for nearly a week in water under stones; when sufficiently retted they are cleaned

by beating them on the ground, the fiber stripped off, washed, and dried. Five hundred stems, about 8 feet high, as grown en masse in gardens, were recently taken at random and the fiber removed and cleaned in the usual way; the result was 5½ pounds clean and good fiber. The stems when carefully dried weighed nearly 20 pounds. Assuming the acre to be 40,000 square feet after allowing for waste patches, the number of stems at 3 inches apart would be 640,000, hence the yield in clean fiber at 1 pound per 100 would be 6,400 pounds, equal to 2⅞ tons; the stems would yield also 11 tons of poor fuel. The yield of three fine stems grown along the ridges in turmeric plantations, and measuring 16 to 17 feet high, was 3¾ ounces of clean fiber, or somewhat over 1 ounce each, instead of one-sixth of an ounce. The dried stems each weighed 5 ounces instead of less than three-fourths of an ounce.

As to uses, a coarse sackcloth is made from its fiber in India (sometimes called gunny fiber), though its chief employment is for ropes and cordage, it being the common cordage of the country in a few districts. Coarse canvas is also made from it. In Bengal it is employed at the present time for all the purposes of jute, and also for making fish nets and paper. Vétillart says:

> The fiber of *H. cannabinus* is stiff and brittle, and has no superiority over jute, and it is very inferior to that of India hemp or sunn. The leaves of the plant are eaten as a pot herb in many parts of India, the taste being pleasantly acid, not unlike sorrel.

The fibers of carefully prepared Ambari are from 5 to 6 feet long. Compared with ordinary hemp they are paler brown, harsher, adhere closer together, though divisible into fine fibrils, possessed of considerable strength. Its tenacity tested with sunn is as 115 to 130.

In the Kew Bulletin for August, 1891, the announcement is made of the discovery, on the shores of the Caspian, of a new commercial fiber plant, known as Kanaff, the fiber of which, "from its abundance and consequent cheapness, and its extraordinary durability, will successfully compete with any other textile for sacking, ropes, and pack thread," with "a greater resistance than hemp." The plant is thought to be *Hibiscus cannabinus*, the Decan hemp plant of India.

Hibiscus splendens (Hollyhock tree).—Fiber from this species, a native of Queensland and New South Wales, is exhibited in the museum of the Department, prepared by Dr. W. R. Guilfoyle, director of the Melbourne Botanic Gardens, who states that the species is a splendid tree, growing to the height of 20 feet or more. "It is very pubescent, bearing large pink flowers resembling hollyhocks in size and appearance." The fiber is suitable for cordage, fish lines, paper, etc. Fiber of *Hibiscus sorbifolia* and *mutabilis* was also received from Dr. Guilfoyle, through the exhibition of 1876. Both of these species are indigenous in Queensland. *H. mutabilis* is a native of China, but grows in India and other eastern localities. Fiber of *H. tetracus* was also received with the above, but does not differ materially.

The *Mahoe* or *Mahaut*, *H. arboreus*, of the West Indies, grows to a height of 16 to 20 feet, and its bark furnishes a superior fiber, which, according to Squier, "is not at all inferior to hemp for most purposes." The fiber is naturally soft and white, and is admirable for the manu-

facture of paper. *H. elatus*, of the West Indies, is employed in making cigarette wrappers. It is a tree that grows to the height of 60 to 80 feet. *Hibiscus tiliaceus* is worthy of passing mention. It is called *majagua* in Central America and the West Indies, where it is much used for cordage. It is little affected by moisture, and is therefore selected by surveyors for measuring-lines. It is the *Bola* of Bengal, and is found throughout tropical and subtropical regions of both continents. The native method of preparing the fiber when a rope or piece of cordage is wanted is to strip the bark from a branch, then, holding one end firmly between the toes, first tearing it in strips, it is twisted by the hands. "It was generally cultivated in America prior to 1492." Beautiful examples of this fiber were shown in the Costa Rican exhibit in Chicago, 1893. There are other species growing in different portions of the world, the fiber of many of which is employed in native manufacture.

OKRA FIBER.

Abelmoschus esculentus.

The okra has long been regarded as a fiber plant of value in India and other countries, though the production of its fiber has never assumed commercial importance. The plant is a native of the West Indies, but it has found a home in southern portions of the United States, where it is grown for its pods, which form a useful article in the domestic economy. It is also cultivated in South American countries, as well as in countries of the Old World, the French estimating it highly as a food plant. In France it is known as *gombo*, and it is the "gumbo" of Louisiana, which is employed in a number of Creole dishes, the best known being "gumbo soup."

During the late civil war, when the Southern States were cut off from communication from the rest of the world by a rigidly enforced blockade, coffee became very scarce and difficult to obtain. During this time many of the people of the Southern States, and especially the poorer classes, utilized the seed of the okra plant by either mixing with coffee or using it alone. They found the seed thus prepared a very fair substitute for coffee.

The plant is a true Hibiscus, the entire family of the *Malvaceæ* furnishing in the bast of their stalks a fiber which, in the absence of jute and hemp, might be employed in the arts for cordage, bagging, and other coarse manufactures. When cultivated for its pods alone the okra plants are grown at considerable distance from each other, and the strength of the plant goes to develop leaves and fruit; but if cultivated for fiber the seeds should be sown thickly and the plants cultivated closer together, that the stems may grow tall and straight and the bark smooth and better adapted to the production of fiber.

A few years ago okra attracted considerable attention as a possible fiber for Southern cultivation, and a large correspondence with the Department resulted, and many articles on the subject appeared in the newspapers of the day. As is frequently the case, however, the value of the plant and the ease of its cultivation for fiber were very much overstated, and subsequent experiments did not substantiate the claims made for the plant.

In color okra fiber is as white as New Zealand flax, much lighter than jute as usually prepared for export, but more brittle and showing less strength. The filaments are smooth and lustrous and are tolerably regular. (For microscopic characteristics of Hibiscus fibers in general, *see* pages 12 and 20.)

Spon states that the fiber is long and silky and generally strong and pliant. When well prepared, as in portions of India, it is adapted for the manufacture of rope, twine, sacking, and paper. In Bengal its fiber is reputed harsh and brittle, owing doubtless to improper treatment, and it is but little manufactured there. In Dacca and Mymensing it is used to adulterate jute. It resembles hemp, and under this name is exported to the amount of a few thousand hundredweight yearly. In France the manufacture of paper from this fiber is the subject of a patent; the fiber receives only mechanical treatment and affords a paper called *banda*, said to be equal to that made from pure rags.

Dr. Roxburgh experimented with okra many years ago in India, and made repeated tests of the strength of the fiber. In preparing the material for these tests, the stems were cut when the seed was ripe, and were steeped a few days before preparing. His tests, compared with hemp and jute, are thus recorded: The okra fiber, dry (from India), broke with a strain of 79 pounds; wet, 95 pounds; jute (*Corchorus olitorius*), dry, 113 pounds; wet, 125 pounds; hemp (Bengal), dry, 158 pounds; wet, 190 pounds. *Hibiscus cannabinus* in the same test gave, dry, 115 pounds; wet, 133 pounds. Other species of Hibiscus gave as follows: *H. sabdariffa*, dry, 95 pounds; wet, 117 pounds; *H. strictus* (from the Molluccas), dry, 104 pounds; wet, 115 pounds; and *H. furcatus*, dry and wet, 89 and 92 pounds, respectively. It will be seen by these tests that okra fiber is not only inferior to that from other species of mallows, but is inferior to jute, and not half as strong as hemp.

A correspondent of the Department, Mr. Felix Fremerey, makes the following statements of his experience regarding the cultivation of the plant for fiber:

> The seeds are thickly sown, on any rich soil, about the beginning of April in the South, and by the beginning of May in the North, in drills 6 inches apart. The seeds can also be sown broadcast, about 20 pounds to the acre; but here much care has to be taken to sow as uniformly as possible. In eighty or ninety days the stalks take a rosy color, and without irrigation they will then have attained a height of from 4½ to 5½ feet, while with irrigation during dry weather they will grow to a length of from 6 to 8 feet, and even more. The stalks can then be cut with a mowing machine, having a dropper attached, 2 or 3 inches from the ground.

In cleaning the fiber Mr. Fremerey's plan was to strip the bark by means of a machine, after which it is steeped in stagnant water for 5 or 6 days, until the fiber is freed from epidermis and gummy matters. The product is then washed and dried.

In 1890 the Moss Collar, Bagging and Cordage Company, of Fort Worth, Tex., became interested in the fiber, and issued a circular entitled "A Word to Farmers," which contained a lengthy account of the production of the fiber and its uses. It was hoped to make the culture of the fiber and its manufacture into bagging a success in order to give a substitute for jute that would enable the farmers of the South to avoid

paying tribute to the "jute trust." I quote a brief extract from this circular:

Okra is destined to become one of the most important fiber plants, for several reasons. It is the most easily prepared for market, and the processes are so simple that any farmer desiring to enter into the culture of the plant need not fear his chances of success. Machinery for decorticating and degumming is to be had at a far less price than machinery for the purpose of preparing cotton. The culture of the plant is as simple as that of corn or cotton. There need be no fear of lack of market for the fiber. It is as salable for cotton bagging, grain sacks, etc., as jute, and as suitable for rope and cordage as sisal and manila. Binder twine can be made from it on the same machinery as that used for either of the above-named fibers. Then, again, it can be used for the manufacture of many of the finer grades of goods, such as carpets, blankets, etc., and the shorter fiber is suitable for the manufacture of mattresses, horse collars, etc.

The company named in the circular offered to sell seed to the farmers at cost and purchase all the product "that could be carted to the mill." The Department carried on a lengthy correspondence with Dr. M. Chambers, who was named in the circular, and was much interested in a machine he was constructing, which, however, was never perfected. A large area was planted in okra near Fort Worth, but the Department was not able, subsequently, to learn how much fiber was secured, if any, or to obtain samples of either fiber or stalks. Like many other such enterprises, the advantages of the culture were very much overstated, and the ratio of cost of production to yield and value of product doubtless appeared, in actual practice, inversely, compared with the golden promises made at the outset of the experience.

Mr. W. L. Van Duzor, another correspondent of the Department, who has cultivated the plant in Florida, writes as follows:

There are two varieties grown here—the dwarf and the giant, or large—and both grow thriftily in our poorest pine land. The dwarf attains a height of 4 feet, and the pods are sufficiently matured for culinary use in three months from planting. The giant variety, and the one I should judge the most valuable for fiber, requires six months to mature, and attains a height of 15 to 18 feet and often lives more than one season. I have seen stalks of okra, two years old, full of tender succulent pods, without a leaf upon the stalks. Not only will it grow from the seed almost without cultivation, but in this climate it will rattoon three years, the last crop nearly equal to the first, it being very rarely injured by frost. I am unable to say what the yield of stalks per acre would be, but I think I could safely say 15 tons.

A South Carolina correspondent, who had experimented with the plant for several years, suggested a novel means of avoiding the use of a machine in stripping the fiber. His plan is to allow the stalks to stand in the field until after frost, when the bast can be easily peeled by hand. The ribbons of stripped bark are then boiled out in water. A claim of 1,500 to 2,000 pounds of fiber per acre by this process is made, at a cost of 2 or 3 cents per pound. Such a plan is not advisable, however, as the fiber would doubtless lose in strength. Then, such crude hand methods of harvesting could not be made to pay, where the fiber must be employed as a substitute for jute, with which it would compete.

Notwithstanding all that has been written upon the subject, and the experiments that have been carried out in different localities in an endeavor to establish the industry, the efforts have not been productive of satisfactory results.

Dr. C. F. Panknin, of Charleston, S. C., who planted a small area in okra, gave the results of his carefully conducted experiments as follows: A half acre of stalks was produced, one half of which, when decorticated by his process, yielded at the rate of 180 pounds of fiber to the acre, the expense being in the neighborhood of $75. The fiber has been used experimentally in the manufacture of paper in Alabama.

From a careful consideration of the subject in all its details, not only as relates to our own but to other countries, and considering the weakness of the fiber compared with jute, I conclude that the cultivation of the okra plant for its fiber can not be made a paying industry in the United States. And this opinion is emphasized by the fact that there are several species of indigenous fiber plants which could be as easily grown and which are superior to jute in strength, while India jute itself will do well in many of the Southern States.

ABUTILON FIBER.

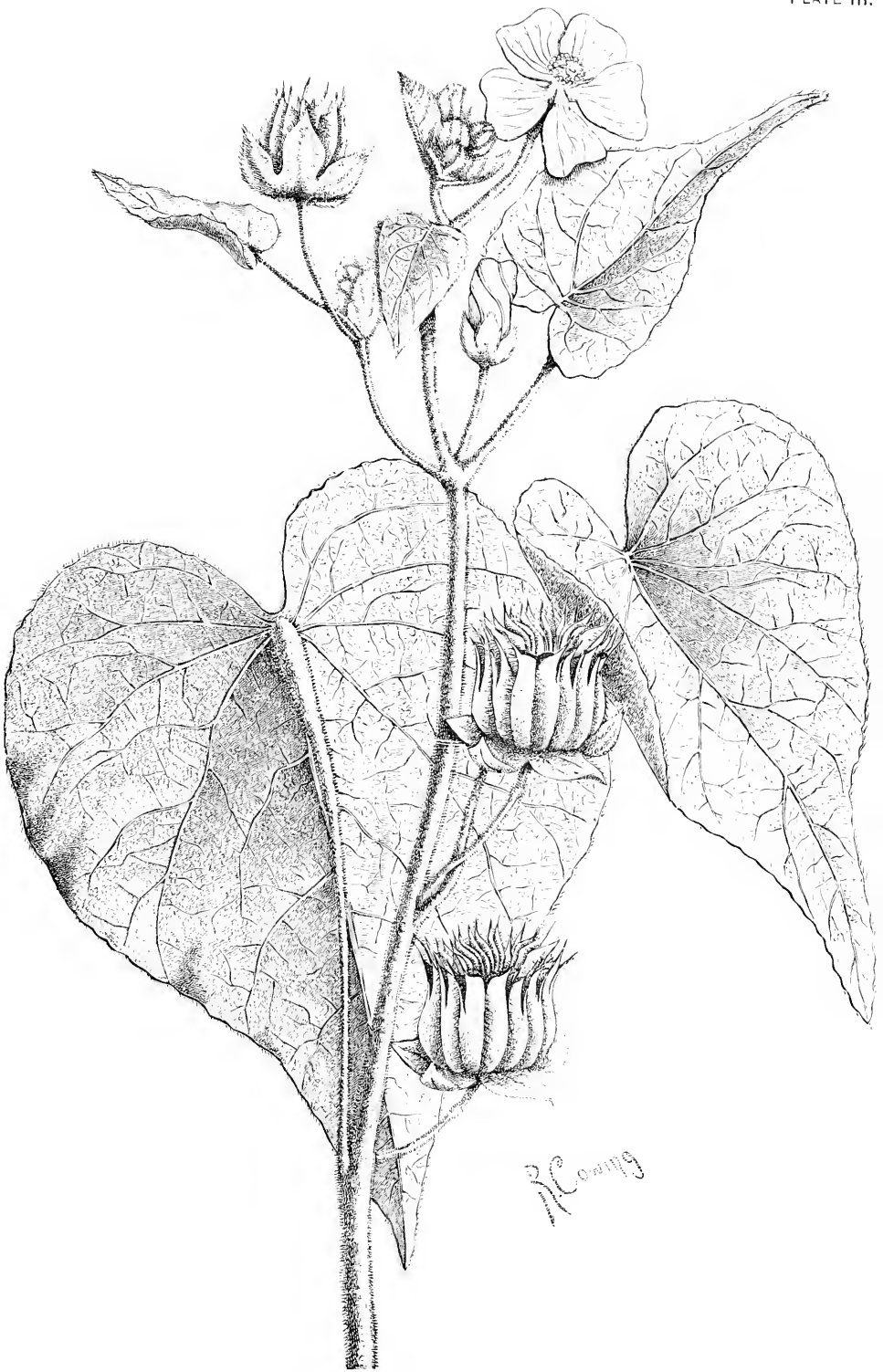
Abutilon species.

A very common malvaceous plant that has been cultivated experimentally in the United States is the Indian mallow (*Abutilon avicennæ*). It is an annual, growing to the height of 4 to 6 feet, though stalks 8 feet or more in length are recorded. Although it has been considered an indigenous species, Gray states that it was introduced from India, and when found growing wild has escaped from cultivation. It is widely distributed, north and south, east of the Rocky Mountains, and is found in the State of Washington. (*See* Plate III.)

Abutilon fiber is known in the Argentine Republic and other South American countries, where it is called *cañapiña*. Its Chinese name is *Ch'ing Ma*, though its fiber has been exported to England under the common name jute. It has also been called Abutilon hemp, and the name "American jute" was once given it in this country, though this designation would prove very confusing were the true jute ever produced in the United States.

The Indian mallow grows so freely upon any rich soil, even thrusting itself in and growing spontaneously, that it has almost come to be considered a farm pest in many portions of the country. It grows luxuriantly throughout the West and North, the line of States from Ohio to Missouri producing even now vast quantities of the fiber, which rots and goes to waste upon the stalks every year. The fiber is strong, glossy, and white, and the ligneous body of the plant gives more cellulose for paper stock than any other species. It has been claimed that fiber extracted from plants that have not reached their maturity will be fine enough to work into yarns for carpet fillings and even fabrics, although I have no doubt the mature fiber if properly prepared could be so manufactured. It takes dyes readily, and an advantage is claimed in this respect over our India jute, which is antagonistic to cheap bleaching and dyeing. The fiber was once classified in value between Italian and Manila hemp, but it will not grade so high, coming nearer to jute, as is proved by its being sold as a variety of jute. The seed of the plant is so hardy that it is not affected by the severest winter, which enables the plant to perpetuate its species in any locality where introduced.

Prof. Waterhouse at one time strongly advocated the cultivation of



THE INDIAN MALLOW (*Abutilon avicennæ*).

this species for its fiber, to which he gave the name "Bute." Fifteen years ago he wrote as follows:

Abutilon avicennæ seems susceptible of development into a source of public wealth. The plant grows throughout the West in rank and wild luxuriance. It has the spirit and capacity of conquest. With invasive march it has taken possession of large tracts of land. Its tenacity of life and rapid spread render its cultivation a far easier task than extermination. There are to-day, in the suburbs of Saint Louis, stalks of abutilon 8 feet in height. Unlike Indian jute, abutilon needs no naturalization. To the manner born, it exhibits a stubborn determination to occupy its heritage.

EXPERIMENTS WITH ABUTILON AVICENNÆ.

Experiments with the plant in cultivation date back twenty-five years at least, when it attracted considerable attention in the West, particularly in Illinois, through the endeavors of Mr. J. H. McConnell to establish the industry. The value of the fiber was demonstrated at that time by its manufacture into twine, rope, etc., and in the report of a State fair committee, in 1871, the fiber was given a flattering promise of utility. According to this report the plants are stated to grow 9 to 14 feet high; the seed should be sown 12 to 16 quarts per acre, in corn-planting time, in the same manner as hemp; it is cut with a reaper, shocked like hemp till cured, then water-rotted like hemp; a volunteer crop will spring up the last of July, which can be dew-rotted. The cost of cutting is given at 75 cents per acre; water-rotting, $10; dew-rotting, $5; hand cleaning, $12; and half as much by machinery, making the total cost, not including rent of land, $19 to $31. Messrs. McConnell offered $100 per ton for all water-rotted that could be furnished and $75 for the dew-rotted. The crop is not exhausting to the soil if the refuse is restored to it.

Seven or eight years later the plant was the subject of special investigation and experiment in the State of New Jersey, through the endeavors of Mr. Samuel C. Brown, secretary of the bureau of labor, statistics, and industries of that State. A circular was issued in 1878 for the twofold purpose of awakening an interest in the subject of fiber cultivation, and to ascertain what portions of the State were best adapted to its cultivation. While the promoters of these experiments were satisfied that no difficulty existed in the cultivation of the fiber, the enterprise failed completely, notwithstanding the fact that a bounty was offered for the production of the fiber.* Since the present fiber investigations of this Department were begun I have received from Mr. Brown a communication on the subject which is worthy of note, an extract from which is as follows:

While I did give much attention to the development of fibers from plants indigenous to New Jersey soil, I am sorry there is so little now to show for the time and

*JUTE.—For every ton of 2,000 pounds of *Abutilon avicennæ* stalks grown in New Jersey not less than 3 feet long, $5; for every ton of 2,000 pounds of what is known as rose or marsh mallow, not less than 3 feet long and not more than 1 inch in diameter at the butt, $5; fractions of not less than a quarter ton in each case will be paid for at the same rate; for every pound of marketable quality of disintegrated jute, 2½ cents. [The term "jute" in this paragraph is a misnomer.—C. R. D.]

money expended in that direction. This is largely owing to a lamentable and prevailing lack of interest and spirit of coöperation on the part of the public. A singular and well-nigh universal apathy exists still in the cultivators of the soil in respect to the introduction of new industries designed to afford new and diversified employment both to skilled and unskilled labor, which is obviously a pressing need of our time and of various sections of our country. I am just as well satisfied to-day as I was years ago that jute can be made a domestic product, and from India seed naturalized in our Middle and Southern States; moreover, that it can be successfully obtained, as a valuable substitute for the India jute, from the rose mallow and Abutilon, which have a wild and luxuriant growth, as you know very well, over the East and West. The want of a cheap mechanical device for decorticating the various fiber-producing plants so abundant in our country remains the impediment to the unlimited production of native fibers.

Commenting on this communication, subsequent investigation by this office inclines me to the opinion that the failure to create this fiber industry fifteen years ago was due more to the lack of proper machinery to economically clean the fiber than to the mere lack of public interest in the establishment of a new enterprise. The machine question is the rock upon which many a promising fiber industry has been wrecked even at a later period.

I give an extract from Mr. Brown's report, which appeared in 1879, in the First Annual Report of the Bureau of Statistics, Labor, and Industries of New Jersey, regarding the value of the fiber:

We have had two interviews with importers of jute, with samples of New Jersey jute fiber in hand. The gentlemen were informed of the circumstances under which our samples were prepared, with the further assurance that they were not equal to what would be produced from the same garden plants later in the season. The quality, however, was pronounced to be very good, and, furthermore, that if we "never produced anything better than that our country had something of great value;" and still further, that "America would become an exporter of jute." *

It was stated, at the time that these experiments were made, that an acre of ground would produce 5 tons of Abutilon stalks, and about 20 per cent of pure fiber would be obtained after preparation. This was considered superior to jute fiber as imported, the long fiber fully equal in value to Calcutta prime jute, and Philadelphia rope manufacturers are reported as having offered to buy any quantity at the highest market price for jute. Bleached and cottonized for fabrics, Mr. Lefranc pronounced the Abutilon fiber good for weaving tissues and for mixing with a certain class of woolen goods. *Abutilon avicennæ* in its crude state was said to be worth from $8 to $10 per ton. In regard to its preparation Mr. Lefranc made statements as follows:

In India, jute is rotted in water and separated by hand from the ligneous body. This method can not succeed in America. As with ramie, machinery and chemicals must be substituted for the production of American jute (Abutilon). As explained in the case of ramie, the jute industry can be most successfully established by organ-

* By "jute," *Abutilon avicennæ* is meant. The application of the name "American jute" to the Indian mallow is an error, as the term should be used only to designate fiber from the jute of commerce (*Corchorus olitorius*) grown in our own country. The name "China Jute" in Fiber Trade Circulars is also a misnomer. (*See* p. 30.)

ized agencies through which farmers could sell their raw crops by the ton. At $10 per ton for dried stalks in proper shape, the grower and the manufacturer could realize, respectively, legitimate profits from the new industry.

That the plant grows in any rich soil suitable for corn and potatoes, and that as a farm weed it is liable to be troublesome, only establish the fact of easy cultivation. The point of culture being settled, the only remaining question relates to the preparation of the fiber, which must be cheaply accomplished, and in a manner that will give the least trouble to the farmer.

That the fiber can be disintegrated and separated from the stalks by steeping in water, like flax and hemp, or jute (as is practiced in India), is well understood, but the steeping pool should be avoided if possible. At the time of the New Jersey experiments it was thought that the question of economically cleaning the fiber had been settled by the invention of a "combined chemical and mechanical process." It was stated that the practical advantage of this refining process consisted in obtaining a vegetable wool so nearly akin to coarse animal wool "as to render their union in coarse fabrics advantageous, and for additional possible uses by itself a valuable substitute." No comment is necessary further than to state that a process which produces anything but clean, straight fiber can hardly be called satisfactory, especially as the principal use of the "vegetable wool" would be in the adulteration and cheapening of the fabrics in which it would be employed. There is no doubt that a combined mechanical and chemical process must be employed in extracting all jute-like fibers, but the process must give straight fiber, uninjured as to strength, and with the natural color preserved. This means a machine that will strip the bark at economical cost and an after-process that will remove the gums without weakening the fiber. Steeping the ribbons in water for the requisite number of days is the simplest form of accomplishing the result, but this is primitive. Nevertheless, machine-stripping and water-retting of the bark is the process adopted by Mr. Fremerey last year in his jute experiments, though I have never seen the figures showing the actual cost of producing fiber in this way.

Douglas Hickox, of Springfield, Ill., patented an improved process for manufacturing paper from Abutilon in May, 1877. A mill was started in Springfield previous to the invention of the process, and several thousand tons of fiber were worked up, but a merchantable paper could not be obtained. Subsequently another process was introduced into the mill, and Abutilon paper was manufactured for about eighteen months, after which the fiber was abandoned and straw used in its place. A series of paper samples submitted for inspection are fair wrapping papers, resembling a light manila more than anything else. The paper was clear and of firm texture.

A small series of samples of Abutilon fiber were exhibited in the museum of the Department eighteen years ago, which were very inter-

esting, though they have since been removed. There were also small samples of rope and twine, probably from the factory started in Illinois twenty years or more ago.

Another use to which the fiber was put, though only to a limited extent, was in the manufacture of a substitute for feather dusters, a few stiff feathers being inserted in a handle in the center of a mass of fiber to hold it out in the form of a duster. Other fibers, as hemp, are used for the same purpose. I had no opportunity to examine manufactures from New Jersey-grown Abutilon, though samples of fiber shown me by Mr. Brown seemed very strong and good.

ABUTILON FIBER IN OTHER COUNTRIES.

There are no records showing that the fiber of *Abutilon avicennæ* is produced commercially in any country but China. By reference to the monthly circular of Messrs. Ide & Christie, the London fiber brokers, the name "China jute" will frequently be found in the quotations of imported fibers. The identity of this "jute" was investigated two or three years ago by the authorities of the Royal Kew Gardens, and it was discovered that the fiber was the product of *Abutilon avicennæ*, and that it was produced in the Hupeh and Szechwan districts of northern China, the locality from which certain grades of imported ramie are derived, as ascertained by this office. In the Kew Bulletin for October and November, 1891, occurs this statement:

Ch'ing Ma.—This is Abutilon hemp, the product of the plant known to botanists as *Abutilon avicennæ* Gaertn. It is commonly cultivated in Hupeh and Szechwan, and is the greater portion, if not all, of the "hemp" passed through the Ichang customs. According to Bretschneider, it is also cultivated in Chihle, and I have little doubt it is what is passed through the Tientsin customs as "jute." In support of this I find in a customs publication that all the hemp exported from Tientsin is called by the Chinese *Ch'ing Ma*, and by the foreign merchants "jute."

Further correspondence brought a report from Acting Consul Hosie, at H. B. M. Consulate Chefoo, on the cultivation of a fiber plant at Chefoo, identified as *Abutilon avicennæ*. The following extract, which relates to cultivation and preparation, is interesting:

This plant, known in the north of China as *Ch'ing Ma*, or more briefly *Ch'ing*, yields the fiber, also called *Ch'ing*, which appears as "jute" in the export returns of the imperial maritime customs. It is an annual. The seeds are sown towards the middle of April in land that has previously been well worked and manured, several seeds being sown together at intervals of about a foot apart, and not more than an inch under the surface. Unless, however, the soil is rich, only one of the seedlings is allowed to mature. In years of normal rainfall the stems, which are branchless with alternate large, smooth, serrated, ovate, acuminate green leaves with long leaf stalks, attain a height of 8 to 10 feet. They are green and supple throughout, with a circumference at the base of from 1½ to 3½ inches. In July and August they bear numbers of yellow five-petaled flowers on stalks, which spring from the axils of the leaf stalks. These quickly fall, and are succeeded by seed capsules of comparatively large size, grooved, and semispherical in shape. Towards the end of August the plants have attained maturity. They are then cut down by knife near the root, and the leaves and tips are lopped off. The stems are made into bundles tied loosely at

the tip end, and placed upright in standing water, so that only the lower halves are submerged. The root halves, being more mature than the upper, require more retting, and for this reason they undergo two days' preliminary steeping. After the lapse of two days the bundles are laid on their sides in the water, and covered with sufficient earth to sink and bring them in contact with the bottom of the pond. In four or, at the most, five days the fibrous peel is loose enough to be easily removed by hand from the woody interior. The fiber ribbons, which have now all but lost their green color, are afterwards washed in clean, cold water and spread out in the sun, and when dry they are of a good white color, such of the external greenness as remains after the retting and washing disappearing in the process of drying.

I have endeavored to learn if any of this "China jute" comes to the American market, for it would be extremely interesting to know if we have been purchasing, even in small quantities, a fiber produced on the other side of the world from a plant that is almost a farm weed in this country. But what can be said when almost the same course is followed in the United States regarding flax?

During my visit to the Kew Gardens in 1889, I was shown a sample of a new fiber plant belonging to this genus which had been received from Trinidad. Subsequently I was able to obtain some fine specimens of both fiber and stalks, the latter fully 12 feet in length. These were the product of *Abutilon periplocifolium*, known commonly as "Maholtine," and the samples were received from Mr. T. J. St. Hill, Port of Spain, Trinidad. From statements made by Mr. St. Hill the plant can be very economically produced, and by simple methods. He says:

It thrives magnificently in barren and rocky soil; the land is simply prepared by burning, when the seeds are thrown broadcast over the plain, about the beginning of the month of May, and the stalks are ready to be converted into fiber one year after. No attention is required to be paid to the plant whilst growing, and wild weeds, etc., do not affect them in the least. Plants growing very near to each other will produce very tall stems, say from 10 to 12 feet high and straight, but those that happen to grow far apart will shoot out branches and make bad growth, and the ribbons will be very irregular—I should say 6 inches from each other would give splendid growth.

When the bark is green it can be peeled its entire length with no other preparation than steeping the stalks in pools of water from five to eight days. The color of the fiber is a creamy yellow, and some of the samples received measured 11 feet 10 inches in length. Samples of the fibers submitted to London brokers were favorably reported upon and valued at £17 to £20 per ton. Seed was obtained and sent to several points in Florida for experiment, but the Department was unable to secure from the experimenters any reports of the results. I wish to state that this is not the only attempted experiment in fiber culture by the Department that has come to naught through the carelessness and indifference of those who undertook the work. In the larger portion of the cultural experiments of the Office of Fiber Investigations it has been obliged to rely upon the voluntary assistance of those having no connection with the Department, and who have undertaken the work without expense to the Government. It is little wonder, then, that occasionally "no results" are reported.

The genus Abutilon has several representatives in South America, all of which yield a good quality of fiber. In the collection of the Argentine Republic at the Chicago Exhibition of 1893, fiber was shown of good length and color, and I am informed that the plants abound in Entre Rios, Corrientes, Missiones, and Gran Chaco territories, where their bast is employed in native uses.

Among Brazilian species may be named *Abutilon mollis*, *A. striatum*, *A. Bedfordianum*, and *A. venosum*, all of which have been introduced into Australia. The last-named species, especially, has been experimented with in Victoria, and, according to Dr. Guilfoyle, is capable of producing "a fine quantity of fiber, suitable for fishing lines, textile fabrics, and paper."

A. striatum is the species commonly met with in greenhouses in winter and growing out of doors (in this latitude) in our gardens through the summer. A sample of fiber was received from the Victorian collection. Its bark, which peels readily, furnishes a fiber of very fine texture. As this plant grows so readily out of doors in the warmer portions of the United States, it might be worthy of experiment. The fiber is of good length, as the shrubs grow to the height of 4 to 6 feet, and, as the bark peels readily, it could be as readily extracted as the other species. *Abutilon oxycarpum* is indigenous to Queensland. A sample of the fiber in the museum is well prepared, white, soft, and lustrous, and appears a little stronger than the Victorian sample. *A. indicum* and *polyandrum* are East Indian species which furnish a strong fiber for rope-making, the first-named growing wild in the Bancoorah district and used as a substitute for cordage in making fences for gardens, but for no other purpose. A beautiful sample of *indicum* was shown in the India collection at Chicago, 1893.

ASCLEPIAS, OR MILKWEED FIBER.

Asclepias species.

The milkweed family, the *Asclepiadaceæ*, contains a large number of fiber-producing plants found in various portions of the world, varying from shrubby growths a few feet in height to the Giant Asclepias of India, which reaches a height of 10 feet or more. The several species in the United States all possess a fibrous bark, and bear seed pods filled with silky hairs resembling thistle down.

The most important species, viewed as a fiber plant, is *Asclepias incarnata*, or swamp milkweed, which, according to Gray, abounds from Maine to Minnesota and southward to Louisiana, being found as far south as the Carolinas on the Atlantic coast. (*See* Plate IV.) A variety, *A. pulchra*, having hairy stems, has almost as wide a northerly distribution, and is also found in North Carolina.

Many specimens of the stalks and fiber of this species have been sent to the Department in the past four years for determination and for statements regarding the utility of the plant, the fiber being thought valuable. As early as May, 1890, the species attracted considerable attention in Minnesota as worthy of cultivation. Among other letters received by the Department was one from Mr. A. E. Ball, of Rushford, Minn., which is produced almost in its entirety. Regarding the plant and its fiber—the species at the time the letter was received not having been identified—Mr. Ball says:

> I believe this plant is soon to become a source of vast worth to the whole country. I sent some of the fiber to J. C. Todd & Co., Paterson, N. J., to whom I refer you for facts. Mr. R. J. Hall, president of the Minnesota State Alliance, to whom I addressed the package, writes: "It (as twine) is stronger than hemp or flax, works with surprising ease, and stands a breaking test of from 95 to 125 pounds, and is pronounced by experts one of the best fibers known; thinks it will make a fine cord that will bring a high price." Mr. Todd wants 200 or 300 pounds to make into binding twine at once. Minnesota can make her own twine at a cost that will save the farmers hundreds of thousands of dollars. I can get this fiber for Mr. Todd, but would have to hire boys to gather it at a probable expense of 50 cents per pound. I can supply you roots enough to set out a thousand acres this year, which would cost probably $5 per hundred, boxed and delivered at the express office, and 500 roots cover an acre. I can gather 100 tons of the fiber next fall from wild plants in the Northwest and save all the seed required to supplant the whole hemp and flax areas of the country, provided I can be set at work with two or three assistants, and a fund to pay labor.

Samples of fiber and binding twine made from it were afterwards submitted to me by gentlemen interested in the product, who visited the Department for the purpose of securing all possible information con-

cerning the utility of the product. The fiber submitted was light gray in color, much finer than hemp as usually prepared, soft and glossy, and was found to possess greater strength than the majority of bast fibers of wild growth in the United States that had been submitted for examination. I stated that, while no better than common hemp, it might pay to cultivate the plant for its fiber, but as hemp culture was an established thing, and hemp was also found growing wild (escaped from cultivation) in the same region of country, I did not think there would be any especial advantage in its cultivation. Instructions were given as to planting close, like hemp, in case the experiment was attempted, from the roots rather than the seed, and suggestions were made regarding the harvesting of the stocks when the plant had finished its growth, in order to obtain the fiber in the best possible condition. As nothing further was heard from these gentlemen, I do not think the experiment in cultivation was attempted or the matter further investigated.

In a letter to Mr. Ball about this time I stated that there was no question but that the plant would produce a good fiber that might be employed for binding twine, but whether he would be able to grow the plants and produce the fiber at a cost of less than 4 cents a pound was another matter. Hemp suitable for binding twine had been shown me that could be sold at a reasonable price. Subsequently, in 1891, I determined to give the fiber a careful test in manufacture, provided a sufficient quantity in proper condition could be secured. The Department, therefore, communicated with Mr. Ball, accepting his offer to secure the fiber at 50 cents per pound for stalks growing wild, and proposed to contract with him for 300 pounds at the price named; or if it was preferable for him to grow the stalks from the roots, a better arrangement was offered, as it was considered that such an experiment would prove more valuable, promising, as it did, more satisfactory results. After considerable correspondence Mr. Ball informed the Department that, inasmuch as it would be impossible to secure the material from a near source of supply he had expected to rely upon, he could not contract to collect the fiber at less than $2 per pound, and the experimental tests were necessarily abandoned. Mr. Ball offered to contract for roots at $25 per thousand.

Later there was some correspondence with Representative Washburne, that was referred by him to this Department, suggesting the appropriation of a considerable amount of money by Congress for experimenting with the culture and manufacture of the fiber. Such an appropriation of public funds was hardly deemed advisable, however, and the matter was dropped.

If a small quantity of the fiber could have been collected and manufactured at a cost not exceeding $250, it would have been money well spent, as it would have enabled the Department to learn all it wished to know that would be of practical value in determining the utility of the fiber in manufacture.

THE SWAMP MILKWEED (*Asclepias incarnata*).

Some of the points favorable to the culture of *Asclepias incarnata* are touched upon in the correspondence referred to, which are worth presenting. Mr. Ball says:

> It can be produced on overflowed land where no other cultivated plant will grow and yield double the fiber that flax will produce. Such lands may be described as bottom lands subject to overflow, of which Minnesota has thousands of acres. The use of such tracts would avoid drawing upon our grain lands.
>
> The crop is perennial and would not need renewing oftener than once in twelve years. The stalks stand well after maturity and can be harvested any time after October 1 without injury to the fiber. The plant will produce as much fiber as a crop of hemp and with less labor. I find it grows as far north as the 46th parallel, and I incline to the opinion that cultivation will carry it up to the British line and perhaps beyond. It blossoms in August, and the fiber does not fully develop until nearly quite ripe, or in September. For this reason a shortening of the season four weeks would injure its value. The Minnesota Valley is its natural home, and it is common to the upper Red River Valley, and thrives in Iowa, Illinois, Missouri, and the States west.

Regarding statements made in the second paragraph, I think the writer is in error in assuming that the plants need not be renewed oftener than once in twelve years. I am satisfied that in six years the soil would become filled with roots and crops of inferior stalks would result. The same mistake has been made in this country regarding the culture of ramie, experiments in India showing that a field should be replanted as often as once in four or five years. Then, too, it is a mistake to infer that because fiber of good strength can be secured from the standing stalks in midwinter the stalks can be harvested at any time. When the fiber has reached maturity they should be harvested to secure the best results. As to the yield of the fiber compared with flax or hemp, positive statements can not be made until an acre or more has been regularly cultivated and the product of a given area weighed after the fiber has been cleaned.

Undoubtedly *Asclepias incarnata* promises better results than any of the indigenous species of bast fibers in the United States that we have considered. If it will thrive upon waste lands, where no other crops will grow, it has to that extent an advantage over hemp, considering the strength of the fiber as fully equal to hemp. I would not wish to make an authoritative statement that it is equal to hemp, however, without some careful tests under known conditions.

The first cost of setting out the plants would be quite large at the price of $25 per thousand for the roots, but this expense would not be incurred again for several years, and after tracts had become regularly established roots in any quantity could be secured at times of replanting or thinning.

As to the value of the fiber in manufacture, I can make no positive statements further than that samples of binding twine examined were found to be strong and good. As the fiber resembles hemp, there is little doubt that it could be employed in all uses to which hemp may be applied.

EXPERIMENTS WITH ASCLEPIAS INCARNATA.

Mr. S. S. Boyce, of Buckley, Ill., a valued correspondent of the Department, was at one time quite interested in this species, which he considers one of the most valuable of our native "hemp substitutes." He has experimented with the freshly grown stalks, and finds that the bast does not yield to treatment readily, whatever may be said of old, weather-beaten stalks found in the field, the source of the binding twine fiber referred to on a former page. In a communication to the Department Mr. Boyce makes statements as follows:

Asclepias incarnata flourishes in low, moist grounds and by slow running streams, growing annually, from a perennial root, some 5 to 7 feet high. It grows in clumps or stools, starting as soon as frosts leave, and seems to assert its position successfully with other shrubbery and weeds. In many respects the plant seems to resemble the ramie; the fiber is soft and silky until the plant is quite mature, and rather difficult of handling by any present known process, but from experiments already made it promises to equal the ramie in fineness and value. The plant may be propagated by seed, but the root may be divided into from 5 to 10 separate plant hills and produce stalks the same season.

It should have an abundance of water to draw from, although plants 4 feet high have been noticed growing upon uplands, but unless set thickly together the plant is shorter and more bushy.

Some stalks were secured from Pennsylvania for exhibition at Chicago, but they came too late to be treated for their fiber, so only the stripped ribbons were shown. These stalks were straight and smooth, about 4 feet in length, grown the previous season.

THE COMMON MILKWEED.

Probably the commonest and best known species of milkweed or "silkweed" growing in the United States is the *Asclepias cornuti* (*A. Syriaca*, of Linn.). Found in Canada, it grows over a wide section of our own country, and is as well known in portions of South America and in the Old World. While so widely distributed it does not seem to have been utilized for fiber beyond limited experiment. The culture of the plant is said to be attended with little difficulty, as it generally thrives on poor soil, and, like the former species, is a perennial. It grows from either the roots or seed, so would be easily propagated if desirable to cultivate it.

The only portion of the plant of which practical use can be made is the bast, which furnishes quite a fine, long, glossy fiber that is strong and durable. Early authorities have given this fiber a place between flax and hemp, and the yield has been claimed to be about equal to the latter. Dr. Schaeffer, as far back as the fifties, made comparisons of the two fibers in Kentucky, and his conclusions were most favorable for the Asclepias fiber. He says:

The native fiber was taken in winter from the decayed stalks as they stood in the ground, where they grew without culture, while the hemp had not only been cultivated but treated afterwards with the usual care. The fiber of the milkweed was nearly, if not quite, as strong as that of the hemp, but apparently finer and more glossy, while the quantity from a single stalk of each was nearly the same.

Among specimens of the fiber shown in the old Glover museum of this Department were some fine examples from Brazil, which had been most carefully prepared, showing that the value of the plant was recognized in that country, though there are no records of its use in manufacture. According to one of the old authorities, "an early knowledge of the fiber of silkweed caused its introduction into Europe, where it has fully become a cultivated plant, while in its own country but little is known of its true value." Dr. Masters, a European authority, states that "its excellent fiber is woven into muslin, and in some parts of India is made into paper." From the Flax and Hemp Commission of 1863 the Department received small pieces of Asclepias cloth mixed with one-third cotton. This, though coarse, is quite strong. From the report of Flax and Hemp Commission (p. 74) the microscopic character of this sample of fiber is given as follows:

> Imperfeetly cottonized, and of course unequal in staple. Some single cells, which could be drawn out, were found to resemble flax in many respects, but differing in decided markings that form long spirals, and also in the diameter of the internal cavity, which is less than that of flax and more irregular. * * * A specimen from Russia shows that the cells will not average more than three-fourths of an inch, if so much.

The fiber forms a good paper material and doubtless might be cultivated with profit for this purpose.

VEGETABLE SILK.

While the stalks yield a good fiber the pods or seed-vessels produce a mass of silk-like filaments, adhering to the seed, which resemble a thistle down. This silk-like substance has frequently attracted attention as a valuable fiber material. From time to time, and in different countries, fabulous accounts have appeared regarding the discovery of a plant producing a vegetable silk that was capable of being woven into the most delicate tissues. Only recently samples of this substance were received by the Department from a Bermuda correspondent, who saw in the cultivation of the plant for its "silk" a possible valuable industry. Experiments in this country have shown that the substance has no value beyond a mere upholstery material, or for use as wadding, and for stuffing pillows. Spon makes the statement that the material is used for stuffing beds in this country, and reference is made to the manufacture of fabrics from it in Russia and France. A French firm has used it by mixing 20 per cent of the "down" with 80 per cent of wool, the fabric being called "silver cloth." The substance could not be used alone, as the cells are so smooth that they have no felting property, and therefore will not hold together and can not be spun. They possess little strength, and can only be considered as "down" or silky hairs, and not as fiber.

OTHER SPECIES.

In the Javanese exhibit at the Chicago World's Fair, two fibrous productions were shown, one a bast fiber of good color and great strength, the other a substance resembling cotton, but of a creamy color. The bast fiber was derived from the Giant Asclepias (*Calotropis gigantea*), a plant common to portions of India and Eastern countries. It is of considerable value in Indian pharmacy, growing wild upon arid wastes, and producing a fiber of superior quality that might be used for many purposes. It resembles flax somewhat in appearance, and is quite strong. It is not cultivated in India, though its fiber is regarded in Madras, where the plant grows wild, as the best and strongest material for bowstrings and tiger-traps. The plant is known under a variety of names, as *Ashar* in Arabic, *Muddar* and *Ak-Muddar* in Hindoo; in Madras it goes by the name of *Yercum*. As it thrives upon soils where nothing else will grow, needing neither culture nor water, it has been considered an advisable plant for bringing waste land under tillage and for reclaiming drifting sands.

Spon states that an acre of ground stocked with plants 4 feet apart each way will yield 10 tons of green stems and 582 pounds of fiber per acre, as prepared by native methods, which waste 25 per cent. The same authority says:

The fiber is said to possess many of the qualities of flax (*Linum usitatissimum*), though it is somewhat finer. Its fineness, tenacity, luster, and softness fit it for many industrial purposes. It is said to be better adapted for textiles than for cordage, and that it may readily be mixed with silk. Yet it shows a high degree of resistance to moisture. "Samples, exposed for two hours to steam at 2 atmospheres, boiled in water for 3 hours, and again steamed for 4 hours, lost only 5·47 per cent, by weight, as compared with flax, 3·50; manila hemp, 6·07; hemp, 6·18–8·44; coir, 8·13."—[Spon.

The mode of separating the fiber, as practiced by the natives, is exceedingly tedious, and would prevent the material from becoming an article of commerce unless some more speedy and less trifling way for preparing it could be discovered. In short, no water is used, and everything is done by hand manipulation, assisted by the teeth. Flax machinery might facilitate the matter if it was desired to cultivate extensively for fiber. As to its cultivation "it is difficult to conceive anything less productive than dry sand, yet the Muddar thrives in it, requiring no culture and no water." Dr. Wight tested samples of the fiber from Madras, where it is much employed for fish lines, and found that it bore a strain of 552 pounds when sunn hemp bore 404 pounds. Royle's experiments gave 160 for Russian hemp and 190 pounds each for Jubbulpore hemp (*Crotalaria*) and the *Muddar* or *Calotropis gigantea*.

A cotton-like substance which is derived from the pods, is similar to the silky hairs of the common milk-weed, though coarser and less silky.

The cotton-like substance shown in the Javanese exhibit was erroneously stated to have been derived from this species. The Javanese name of the fiber is Kopak, and the Kopak of Java—which is exported to Holland in commercial quantities as an upholstery material—is the product of a malvaceous plant, *Eriodendron anfractuosum*. The cottony fiber of *Calotropis gigantea* is said to have been manufactured into shawls and handkerchiefs, but I can not think it possesses sufficient strength to be spun alone. I am aware, however, that a soft kind of cloth has been made from the "down" of this tree by mixing with cotton. It has also been used in the manufacture of paper.

There are several other species of plants belonging to the *Asclepidaceæ*, that are known to the vegetable economy as fiber producers, and found chiefly in the Old World. Among these is the *Marsdenia tenacissima*, Rajmahl Bowstring Creeper, the plant producing the *jeetee* fiber of India. There is no sample of the fiber in the Museum, but as it is often referred to, and is well-known, it will be proper to mention it. It grows in the Rajmahl hills of India in dry and barren places, and the fibers of the bark are employed for making bowstrings by the mountaineers. "The fibers are not only beautiful in appearance, but strong and durable." In Dr. Roxburgh's tests of twine made from *jeetee*, he found that in the dry and wet states it bore a strain of 248 and 343 pounds, when hemp in the same state bore 158 and 190 pounds. More recent tests, however, place it below hemp in strength, but above it in elasticity. The fiber is much used for making nets, and is not liable to injury by being kept in water.

COLORADO RIVER HEMP.

Sesbania macrocarpa

The botanical family *Leguminosæ* contains many species of plants giving a strong bast fiber, some of the foreign species having a known commercial value. In our own country the single genus *Sesbania* of this family has attracted attention as fiber-producing plants.

Specimens of the straight stiff canes of the *Sesbania macrocarpa*, or wild hemp of the Colorado River region, have been sent to the Department at different times in the past twenty years, the best samples of stalks and fiber having been received from the veteran collector, Dr. E. Palmer. Dr. Parry, formerly Botanist of this Department, informed me many years ago of the abundance of the species on the alluvial banks of the Colorado, and also stated that it grew in South Carolina, Arkansas, and Texas. The fiber of this Museum sample, now loaned to the Columbian Museum in Chicago, is 3 to 4 feet long. The filaments as extracted are exceedingly coarse, and resemble flat ribbons of fiber, uncommonly white and lustrous, and clear and smooth to a remarkable degree. Single filaments are quite strong, but when several are twisted together they lose a part of their strength, a defect sometimes observed in better fibers. It is somewhat elastic, but its smoothness and elasticity are not in its favor where tenacity is required, as the filaments will not cling when worked together. It is sufficiently strong for small cordage for ordinary use, though too coarse for fishline or twine, as roughly prepared.

EFFORTS TO UTILIZE SESBANIA MACROCARPA.

Within a few years the plant has again been brought into prominence by correspondence and through articles which have appeared in the press of the Southwest, and efforts have been made by the Department at different times to secure a sufficient quantity of the fiber to test its value in manufacture. Among the early communications on the subject made to the Office of Fiber Investigations was one from O. F. Townsend, of Yuma, Ariz., who says:

> An indigenous plant commonly known here as wild hemp, producing a fiber of great excellence, grows profusely on both sides the Colorado River from Yuma to tide water at the Gulf of California. The large fields lie in Mexican territory and cover nearly 100 square miles of area. Numerous experiments have been made with different kinds of machinery to utilize the valuable plant. The old hand-brake system produces 20 per cent of fiber. The Indians work it into nets and fish lines.

Later the Department was in correspondence with Mr. D. K. Allen, editor of the Yuma (Arizona) Sentinel, in relation to the securing of

fiber, and more recently with Mr. James Madden, land agent of the Southern Pacific Railroad, who was asked to aid the Department in securing about 200 pounds of the product. The Department was unable, however, to learn of any one who would contract for the quantity of fiber desired and the matter was deferred. Mr. Allen has made some interesting statements relating to the growth of the plant and also regarding the expenses of cutting and harvesting the stalks, extracts from which are here reproduced:

The wild hemp ripens from the 1st to the 3d of July, as a rule, and still in many places it holds green until September 1, and the late growth until October 1. It grows on the clean clear soils or lands lying along the sloughs or branches of the Colorado and New rivers, which are dry during the fall and winter months. Our first rise in the Colorado comes in February and lasts into March. The second comes in May and June and runs off from that time on till the next February. The seed of the wild hemp sprouts and begins to grow in April and May and runs up and looks exactly like wild or overgrown mustard stalks—in fact, one could hardly tell one from the other except for the difference of taste in the seeds. When young they are not at all alike. As soon as the water recedes in August, and from that on, you can go almost where you please over and through the hemp lands, although some of the sloughs or branches of them contain a little water and would have to be bridged. But they are very narrow, only 10 to 20 feet and only 2½ to 5 feet deep, with plenty of wood, brush, and timber with which to build the bridges.

Some of the hemp can be cut with a machine, but much of it will have to be cut by hand. In April I could have shown stalks of the hemp that, a foot above the ground, measured 10 inches in circumference, or more than 3 inches in diameter. One of the McCormick reapers, rigged with guards of the proper size and with a sickle to correspond, can be arranged so as to cut easily where it is not larger than a man's finger.

The hemp can be dried and pressed into bales on the ground where it grows. It now grows all along the river and back from it for 10 to 12 miles, for a distance up and down it for 100 miles. Many of the sloughs where water remains throughout the year can be used. Flat boats that can carry 10 to 15 tons can be loaded and towed with horses or mules, poled or towed by Indians when the banks are too soft. Sails can also be used to take the hemp to the river where it can be loaded on steamers and brought up to the railroad, or down the river to the gulf where it can be loaded onto vessels for any port in the world.

My estimate is that at the very least there are 50,000 acres of it, and that in the poorest years it will yield 500 pounds of the dressed fiber per acre. This makes 25,000,000 pounds—12,500 tons, or 1,250 car loads of 10 tons each. This is the lowest estimate ever made by any one. There are years, for instance last year and this, when there was and will be at the very least four times as much per acre. We calculate that two good Indians will cut or pull an acre a day, and pile it up so that it can be handled, or say, on the average, one Indian will gather 500 pounds of the clear fiber per day. The hemp grows on the average to be about 9 to 12 feet high, and I have had stalks that measured 32 feet in length.

Among the manufactures for which it has been claimed that this fiber is fitted are wrapping, writing, and bond papers, twine and cordage, "sacking, overall stuff, Irish linens;" and a fabric "better than the best Japanese Pongee silk." Judging from the Museum samples of fiber, collected by Dr. Palmer and known to be from *Sesbania macrocarpa*, I do not think it capable of manufacture into "Irish linens" or "Japanese Pongee silk," although the filaments can be very finely divided. A specimen recently submitted to Dr. Thomas Taylor was

subdivided down to one ten-thousandth of an inch. As the plant grows wild over such an extended area, it is important that a quantity of fiber should be secured sufficient to make a thorough test of its value before making positive statements regarding its utility.

The fact that the stalks of one sample submitted to me as the Colorado River hemp and partially treated had not the smooth cane-like appearance of the *Sesbania*, being more irregular, like hemp, suggested to me the possibility that there may be two species of fibrous plants growing in this region. The appearance of the stalk of *Sesbania* is unmistakable. The specimen referred to had some of the peculiarities of a common hemp stalk.

Even considering the coarseness of the fiber, should it be found quite inferior to the commercial cordage fibers, the fact that it grows over such vast areas without cultivation, and with such large yield, commends it to our attention, for if it can be cleaned cheaply it has a value for some purpose, and when subdivided by after chemical treatment there is no doubt that the fiber might be used for higher purposes of manufacture.

Sesbania vesicaria.—Mr. P. S. Clark, of Hempstead, Tex., in correspondence with this office, states that this species suddenly made its appearance in his neighborhood, "and seems to have come to stay." He describes the fiber as very strong, and thinks that it would make a good bagging fiber for baling the cotton crop.

FOREIGN LEGUMINOUS FIBER PLANTS.

While treating of American species belonging to the *Leguminosæ* it may be well to consider a few species which are of commercial importance in the Old World. *Sesbania aculeata* produces the well-known *Dunchee* fiber of India, which is highly esteemed for the manufacture of ropes and cordage, and is regarded as a coarse substitute for hemp. The plant is a native of the Malabar coast, and also grows in China. In Bengal it is called *Jayunti*. The plant grows to a height of 6 to 10 feet; the fiber is long, but much coarser and harsher than hemp. Bengalese fishermen make the drag-ropes of their nets of this substance, on account of its strength and durability. It is generally grown in wet soil, requiring little preparation, as the plant is hardy and of rapid growth. It is sown at the rate of 30 pounds of seed to the acre. In Northwest India, during the rainy season, it springs up in rice fields, and other wet, cultivated lands. A peculiarity of the fiber is its remarkable contractability, as from contraction alone ropes made of it are said to be able to carry away the mainmast of a ship.

Crotalaria juncea.—Early in 1893 the Department imported a small quantity of seed of the well-known sunn-hemp plant of India. It came too late to distribute to southern localities for experiment, but a little of the seed was planted in this locality. It made a fair growth and early came into blossom, but the growth was small and the fiber not fully matured at the end of the growing season, and the experiment

seemed to demonstrate that the plant is not suited to the latitude of the District of Columbia. The seed has been distributed to fifteen southern stations and localities for test the present year.

Its Indian names are *Chun-pat* and *Chumese;* Sanscrit name, *Sana;* the fiber is known as sunn (or san hemp), Taag, Cankanee hemp, Indian hemp, brown hemp, and Madras hemp. Sunn hemp is "probably one of the earliest of the distinctly named fibers, as we find, in the Hindoo 'Institutes of Menu,' that the sacrifical thread of the *Cshatriya*, or Rajpoot, is directed to be made of *sana*." The plant producing this fiber is a shrub growing from 8 to 12 feet high, with branching stem marked with longitudinal furrows. When cultivated it is sown quite close, at the beginning of the rainy season, in order that the plants may grow tall and thickly together—the natives say, the thicker the better, so as to prevent the air passing through it—80 to 100 pounds of seed being used to the acre, and some even sow a larger quantity. In some portions of India two kinds are cultivated, one sown in May and June, when the first showers fall, and the other in October, though in quality they are the same. "That sown in June is cut in August and September, and the other about April."

In the Dictionary of the Economic Plants of India there is a full account of the treatment of the plant in cultivation, from which extracts are reproduced:

In Kolaba it is sown in November, after the rice is harvested, and the stalks are uprooted in March. In Kolhapur it is sown in August and harvested in December by being cut when the plants are full grown. In Poona it is sown in July and ripens in October. In the central provinces and the northwest provinces it is a *kharif* crop, being sown with the advent of the rains; but in Bengal it is sown a little earlier, namely, from 15th of April to 15th of June; in Madras the sowings take place even still earlier. In the experiments performed at the Saidapet farm, Madras, sunn was shown on the 2d of February. In the *Ain-i-Akbari* the plant is described as bearing its yellow flowers in spring, a fact which Mr. Hem Chunder Kerr (writing of Bengal) expresses some astonishment at, since "it now flowers in the rainy and cold seasons." Roxburgh says it is sown in Bengal in May and June, and flowers by August—that is to say, towards the end of the rainy season. In the last agricultural report of Bengal it is stated that the crop is harvested from 15th of August to 15th of September.

It requires a light but not necessarily rich soil, and it can not be grown on clay. It is, therefore, sown on the high sandy lands less suited for the more important crops. Wisset remarks that clay soils are injurious, but that on a rich soil the fiber is of a coarser quality than that grown on dry high situations.

The opinion prevails all over India that high cultivation is not necessary for sunn hemp. Of Kolaba it is said, "The soil is roughly plowed twice and the seed sown broadcast." In Bengal "the seeds are sown broadcast. It is necessary to have the plants grown thick, otherwise they become bushy and coarse and give very inferior fibers." "There is nothing more required after sowing till harvest time." In the northwestern provinces "two plowings at most are given, and the seed is sown broadcast and plowed in. It germinates quicker than any other crop, the seedlings showing above ground within twenty-four hours after being sown. Irrigation, even when necessary, is rarely given, and no weeding is required." In the experiments made in Madras, to which reference has already been made, it was apparently sown in drills. "The land was prepared for an ordinary crop by plowing and harrow-

ing until it was reduced to a proper state, and the seed was then sown with the drill in rows 9 inches apart at the rate of 12 pounds per acre," but in the northwestern provinces about 1 maund (or 80 pounds) to the acre is general. In Bengal 20 seers (40 pounds) to the *bigha* (three-fourths of an acre) is the customary amount of seed. Roxburgh states that from 80 to 100 pounds weight to the acre were used in his time. The plants should not be more than 2½ to 3 inches apart each way, and hence thick sowing is desirable.

In most cases the plants are pulled up by the roots; in others the stems are cut with a sickle close to the ground. Of the Poona district, Bombay, it is stated that the crop is "left standing for about a month after it is ripe, that the leaves, which are excellent manure, may fall on the land." It is not clear whether the crop is left on its roots—that is to say, not reaped—or whether it is cut and stacked on the fields; the latter more probably. The greatest difference of opinion prevails as to whether the cut crop should be dried before being steeped, or, like jute, be carried at once to the retting tanks. But even with jute some cultivators dry the plants sufficiently to allow of the leaves being rapidly stripped, since these are supposed to injure the color of the fiber if allowed to rot in the water of the tank. With regard to sunn hemp, the general rule may be almost safely laid down that in moist regions, like Bengal, rapid submersion is preferred, and in dry regions, like Madras, stacking the crop is practiced. Roxburgh from actual experiments arrived at the opinion that "steeping immediately after the plant is pulled is the best, at least in Bengal during the rains, for then it is very difficult to dry it and the fiber becomes weakened and the color injured."

The average yield of fiber is about 640 pounds per acre. In preparing the fiber in the Lucknow district the stalk is cut near the root when the plant begins to flower, "tied in large bundles, and immersed in water, the natives putting small weights upon it (generally mud) to prevent it being carried away. After remaining in water from four to eight days it is withdrawn, taken by handfuls, beaten on a piece of wood or stone, and washed till quite clean and the cuticle and leaves entirely removed." The woody portion is separated by further beating and shaking when perfectly dry. At Commercolly the plants are pulled, tied in bundles, and are then left standing in water on their roots to the depth of several inches. This allows the fiber to obtain the right degree of firmness without becoming parched and dried by the sun. Oversteeping causes the bark to separate very easily, but weakens the fiber. Dr. Roxburgh found "no advantage, but the reverse, by drying the plant after maceration and before the bark is removed," which is the mode practiced in regard to flax and hemp. After the fiber has been separated it is thoroughly washed, by repeatedly squeezing and wringing the water out of it, after which it is hung upon lines. When dry the fiber is separated a little, or combed with the fingers, and then bundled for market.

In another account it is stated that small pools of clear water, well exposed to the sun's beams, seem best suited for the steeping, because heat hastens maceration and consequently preserves the strength of the fibers, while clean water preserves their color.

Having discovered that the necessary degree of retting has been attained, the cultivator, standing in the water up to his knees, takes a bundle of the stems in his hand and threshes the water with them until the tissue gives way and the long, clean fibers separate from the central canes. According to some writers the retting stems, after being partially washed, are taken out of the water and placed in the sun to dry for some hours before being beaten out in the way described. This practice, while it is followed in some parts of the country, is condemned in others as injurious, or at least as a useless delay.

The drying is usually accomplished by hanging the fiber over bamboos to be dried and bleached by the sun. Naturally, in this country, such primitive processes as are described above would never be resorted to. They are interesting, however, and some valuable points may be gained from the experience.

When the plant first began to attract attention among Europeans it was believed the Hindoo method of treatment could be improved upon with favorable results, but much opposition was raised by the natives, who declined strenuously going out of the beaten track of their fathers. It was found to be a much more delicate plant than hemp, and consequently could not be prepared after the European methods without a modification of the processes.

As to tenacity, experiments made with fiber grown and prepared under the supervision of the agent of the East India Company gave a result which, when compared with the best Russian hemp, was in the proportion of 4 to 6, sunn being the weaker. Royle states that while "some recent sunn broke with 170 pounds strain, when Russian hemp broke with 160 pounds, the former may not bear the same degree of twisting as the latter." In Dr. Wight's experiments with sunn, cotton rope, hemp, and coir, they were found to stand a strain of 407, 346, 290, and 224 pounds, respectively. The fiber is used principally for ropes and cables, though in India it is manufactured into cordage, nets, sackcloth, twine, and paper. The finely dressed and most carefully prepared fiber is made into canvas of great durability.

The Jubbulpore hemp (*Crotalaria tenuifolia*) has been considered by some authors to be a variety of *C. juncea*, and is said to be superior to Russian hemp (*Cannabis sativa*), breaking approximately at a strain of 95 pounds for the first named to 80 pounds for the latter. It is 4 to 5 feet in length, and resembles best Petersburg hemp, compared with which Royle considers it equal, if not superior. Although its cultivation is limited, it is regularly grown for its fiber, which is used for the same purpose as sunn.

There are several other species of Leguminous fiber plants, which grow in the tropics, and in South America and India. They are generally climbers. In the Museum are two large coils of rope made from the Chain Creeper (*Bauhinia splendens*) that were received from Brazil and Venezuela. In the last-named country the tree is called *Bejuco de Cadena*. Dr. Ernst, of the Venezuelan Commission, says the plant is common in the hot, damp forests. "The stems are extremely flexible and tough, so they can be used as cords, being more durable than iron nails, which in the damp atmosphere rust very soon and give way." The ribbon-like strip is very dark—almost black—and the cordage made from it is of the very coarsest description, the entire bark often, as peeled from the tree entering into its structure unbroken. The two cables are about an inch each in diameter. *B. racemosa*, known as the "Maloo Climber," abounds in the valleys of the Himalayas. *B. scandens* is an Indian species, about as strong as sunn-hemp.

MISCELLANEOUS FIBERS.

Having described the more important species of uncultivated bast fibers, it only remains to mention a few forms of lesser importance that have been the subject of occasional inquiry, or of limited experiment. Among the species of lesser importance which from time to time have been submitted to the Department are a few containing fibrous material in their bast, but of such inferior quality that they can hardly be considered as fiber plants, burdock being an example. Many experiments with such plants have been zealously carried on in this country that would have been more wisely directed in other channels, the possible commercial value of the fiber to be obtained seemingly not having been considered. In a sense "fibrous substance" is found in many of the common plants growing all about us, and some of these while not adapted to the production of "textile fiber" might have a fair paper stock, though the ratio of cost of reduction to value of product obtained must always determine the question of their utilization. It is not proposed, however, to discuss paper materials in this report, though they may be given a passing mention in a future report on miscellaneous American fiber plants.

INDIAN HEMP.

The Indian Hemp plant, known botanically as *Apocynum cannabinum*, has long been regarded as a useful fiber plant by certain tribes of North American Indians. From it they manufacture, in rude fashion, bags, mats, small ornamental baskets, belts, twine, and other cordage, fishing lines, and nets. The fiber is easily separated from the stalk, and when cleaned is quite fine, long, and tenacious. In color it is light cinnamon, as usually seen, though finely prepared specimens are creamy white and remarkably fine and soft. Samples of the fiber have been received at various times from Minnesota, Nebraska, Utah, Nevada, and Arizona, together with a great variety of articles of Indian manufacture. The finest prepared specimen is a fish line, such as is used by the Pi-Utes at the Walker River Reservation in Nevada. The fiber will rank with Asclepias for strength, and is readily obtained, as the stems are long, straight, smooth, and slender. Although paper has not been made of it, it could doubtless be utilized for that purpose.

The plant, which is indigenous to the United States, is a perennial herb, belonging to the dogbane family, with upright branching stems, 4 or 5 feet in length, having opposite leaves, and a tough, reddish

bark. (*See* Plate v.) Spon mentions the species, but gives it the common name "Colorado hemp," which does not apply to this species but to *Sesbania macrocarpa*, previously described. He states that "it yields a fine, white, strong fiber." The naturally prepared fiber of the specimens of *A. cannabinum* that have come under my notice are always a dark cinnamon color, and not white, and it may be that the two species have been confounded by European writers.

In the Russian exhibit at the Columbian Exhibition, was shown a beautiful sample of Apocynum fiber, about 2½ feet in length, and dark salmon in color, which it was claimed was used commercially in Russia to a limited extent.

There are several foreign species, as *A. sibiricum*, *A. syriacum*, etc., which abound in Southern Siberia, Turkestan Trans-caucassia, and on the Adriatic, and that produce fiber employed for cordage, fishing nets, lines, and other uses. Spon states that in some districts, where the fiber is more carefully prepared, it is manufactured into textiles. "It is separated by a short retting, is strong and elastic, easily divisible, bleaches and dyes well, and has a length of 6 to 12 feet."

THE NETTLES.

Urtica gracilis, one of the stinging nettles, abounds throughout the United States and Canada. As it is related to the ramie plant it naturally possesses a good fiber in its bast, though the stinging hairs which clothe its stalks and leaves make it unpleasant to handle. Its fiber, gathered from weather-beaten stalks found standing in the fields, has been sent to the Department from various localities. A few years ago it attracted attention in Minnesota, and an attempt was made to reduce the fiber, though the experiment was interrupted before completion and no report could be made. From a communication to the Department by Mr. J. Carmichael Allen, in 1891, the following extract is produced:

> I have about a half ton of the straw of *Urtica gracilis* retting and will furnish you with samples of the fiber as soon as ready. It seems a close relative of the *Bœhmeria* fiber, though whether dew-retting will prove a successful system or not for this plant I shall not be prepared to say until I scutch some of it. I inclose a sample of tow I made from a few of the stems this afternoon. You will see it is not sufficiently retted and the fiber though soft does not appear to be over strong. From the nature and feel of it I expect it will be better adapted to mix with wool than as a substitute for flax, and this comes more under the Rhea class.

It may be stated that the fiber of *U. heterophylla*, which is found in Coromandel, Nepal Burma, Assam, etc., is known as vegetable wool, and it is claimed that the filaments of this species, "having a rougher surface than those of *Bœhmeria nivea* (ramie), are, therefore, more easily combined with wool in mixed fabrics."

I have never seen a properly prepared sample of the fiber of *U. gracilis* from fresh stalks and am unable to describe its characteristics in this particular.

Laportea canadensis.—This is another stinging nettle which produces an average quality of fiber. Samples of both stalks and fiber were received by the Department from Kansas, in 1890. The name Indian hemp is sometimes given to the species, but it is a misnomer, the true Indian hemp being an *Apocynum.*

THE COMMON BURDOCK.

Several years ago the stalks of the common burdock, *Arctium lappa*, were the subject of experiment by Mr. W. W. Ball, of La Salle, Ill., who hoped to produce at low cost a fiber material suitable for binding twine. Specimens of the stalks and samples of the "fiber," both straight and in the form of "tow," were submitted. The filaments were found to be harsh and wiry, very brittle, and possessing little strength. A small sample, extra treated, was yellowish in color, very soft and pliant to the touch, but absolutely worthless as to strength.

It was claimed that the plants could be produced in quantity in new or waste land, and could be cut, crushed with a cane mill, and the bast steeped in pools of water at small cost, the fiber to be stripped by children. It was suggested that the softer fiber, referred to above, could be employed in upholstery, and even in fabrics, or could be prepared as paper stock.

It is almost needless to say that "fiber plants" of this class have no value in the industrial economy, the fibrous material contained in their bast being too inferior ever to be used in manufacture where so many other better fibers are obtainable that may be produced possibly at less cost. This form of "fiber plants" illustrates a large class that have been the subject of experiment from time to time, but it is not necessary even to attempt their enumeration.

TREE BASTS.

Another form of fibrous material which has been employed to a certain extent in the coarsest of manufactures, if manufactures they may be called, are the tree basts, or the fibrous inner bark of such trees as the linden and cypress. The linden trees are familiar in our public parks and gardens, where they are cultivated for adornment, though as lumber they are known as basswood. *Tilia Americana* is the American representative, while *T. Europæa* abounds in the Old World. The inner bark of the American species has not been utilized so far as I am aware, but the bast of the foreign species is much employed in Russia in the manufacture of an exceedingly coarse kind of rope for making the matted shoes worn by the peasantry, and also for the manufacture of the mats which are used to a considerable extent by furniture dealers for packing. They are also used by gardeners as a covering or protection to glass frames. For the larger and better kinds of mats, trees 8 to 16 years old are used, which are cut when full of sap,

THE INDIAN HEMP PLANT (*Apocynum cannabinum*).

INDEX.

A.

B.

P.

R.

S.

T.

U.

V.

W.

O